

**SAN DIEGO COUNTY
DEPARTMENT OF ENVIRONMENTAL HEALTH
LAND AND WATER QUALITY DIVISION
SITE ASSESSMENT AND MITIGATION**

USERS GUIDE TO THE VAPOR RISK 2000

Version: November 1999
Excel 97 Spreadsheet Model

I. INTRODUCTION

The vapor transport and risk calculations used in the Vapor Risk 99 application is outlined in detail in the 1999 edition of the Site Assessment and Mitigation Manual (SAM Manual). The application uses the conceptual model of diffusive transport of volatile organic vapors vertically through a homogeneous soil into a structure. The model assumes that the contamination is from a non-diminishing source and is in dynamic equilibrium in the soil pores. Buildings with basements or other subterranean structures may require more complex analyses that consider advective or pressure driven flow.

This model can be used to establish constituent health risk-based estimates of exposure to vapors from a contaminated site. The volatile hydrocarbon chosen for the health risk assessment will vary depending upon the nature of the contaminants observed at a site. Most commonly, these compounds will be benzene and other aromatic hydrocarbons for fuel contaminated sites, and tetrachloroethene (PCE) and trichloroethene (TCE) for releases from dry cleaners and vapor degreasers.

This application is a simplified environmental fate and transport analysis to evaluate the inhalation exposure pathway only.

II. LEVELS OF COMPLEXITY

As presented in the 1999 SAM Manual there are three levels of exposure calculations. This application provides options for each level of evaluation.

Level 1

This level uses conservative default values presented in Tables 7-2(a), 7-4 and 7-9. The values used are already preset in the spreadsheet when you open the application.

Level 2

This level allows you to incorporate site-specific parameters instead of using the default values in the level 1 analysis. The common site-specific information includes various soil properties, exposure duration, slab attenuation factor and/or air exchange rate. Technical justification must be provided to use values other than the default value. In general, the level 2 analysis is going to be more representative of site conditions and will result in a less conservative estimate of risk. It is

recommended that in any analysis, a range of parameter values be used as model input to evaluate the sensitivity of the model to variations in specific parameters. Site-specific information should be used for the most sensitive parameters.

Level 3

This level as presented in the 1999 SAM Manual, allows for modifications to the vapor diffusion model or the use of more complex models. This application provides a modification of the vapor diffusion model as presented in the SAM Manual to allow the vapor flux through the floor slab to be less than the total floor area.

III. LIMITING ASSUMPTIONS

The following are key assumptions that must be considered when applying the vapor risk model to a site. If these assumptions do not apply, this vapor risk model should not be used.

- The geology is homogeneous and isotropic. The stratigraphic variability and horizontal variation within a stratum are not considered.
- Vapor diffusion through air-filled soil pores is the only transport process considered.
- Vapor diffusion is one-dimensional. All chemical vapors move upward from below-grade sources (free-product, soil or groundwater).
- The model is not an evaluation of the entire inhalation risk. Only the chemical coming from the subsurface contamination source is considered.
- The source is a non-diminishing concentration; biodegradation, chemical oxidation, and hydrolysis are not considered.
- The size of the contaminant plume is fixed.
- The volume and mass of source is not considered.

IV. SPREADSHEET LAYOUT

The Vapor Risk 99 application is contained in four separate spreadsheets. These spreadsheets are labeled as follows:

- Input Data
- Health Risk Calculations
- Properties Table
- Health Risk Factors

A. **INPUT DATA SPREADSHEET** – This spreadsheet is the location where the various input data is entered. This is the only spreadsheet that allows data input and editing. The data input is divided into the following areas.

Chemical of Concern – By entering the chemical name in the highlighted area the chemical properties will automatically be entered into the “values used” column for the various chemical properties, the chemical reference dose and the slope factor. By entering the cell number that is listed in front of the chemical

name, for example "+C11", this will result in the chemical name "benzene" being entered into the field. If the chemical you want to evaluate is not listed, skip this field (make sure it is blank) and enter the chemical properties, the chemical reference dose and slope factor in the "Site-Specific" column.

Chemical Mixture – This field is required to be filled in when the contamination is a mixture and when the, compound of concern, concentrations are greater than 100 mg/kg. If the chemical is not a mixture, leave this field blank. By entering the cell number that is identified in front of the specific mixture name, for example "+C27", this will result in "Gasoline" being entered into the field.

Site-Specific Information - The items listed under the site-specific information are related to the chemical concentrations measured on-site. This application will only calculate risk using one input concentration (calculated from free-product, soil or groundwater or field-measured soil gas concentrations). If the data is entered in a way so that the application has a soil gas result for more than one of the methods, the application will calculate risk in this order:

- Measured soil gas
- Free-Product and Soil greater than 100 mg/kg
- Groundwater
- Soil contamination less than 100 mg/kg

a. **Calculation of Soil Gas from Free-Product and Soil with Concentrations Greater Than 100 mg/kg**

- 1) The Mole Fraction (MF) of a chemical in a mixture is defined as the molecular fractional part of the chemical to the total mass of the mixture. For benzene in gasoline, the commonly used mole fraction values are 0.01 or 0.03. The default value in the application is 0.03. When the total concentration of the compound or mixture is greater than 100 mg/kg the mole fraction method must be used.
- 2) Temperature (T) – The default temperature is considered to be 293° K (20°c). Other temperatures may be used but justification must be provided.
- 3) Soil concentration (TPH/TRPH) (CTPH) – The application will calculate the mole fraction when there are values entered into the Soil Concentration (Chemical) field and the Soil Concentration (TPH/TRPH) field. These two values must be from the same soil sample.

b. Calculation of Soil Gas from Contaminated Groundwater

Water concentration (chemical) (C_w) – To calculate vapor risk from dissolved contamination in groundwater complete this field. Use of values other than the default values provided, must be documented and specific justification must be provided.

c. Calculation of Soil Gas from Soil with Concentrations Less than 100 mg/kg

Soil concentration (chemical) (C_t) – This field must be completed to calculate risk from residual soil contamination. This calculation only applies at concentration less than 100-mg/kg residual TPH or when you want the application to calculate the mole fraction at concentrations greater than 100-mg/kg residual TPH.

d. Measured Soil Gas Concentration

- 1) Soil gas concentration (measured) (C_{sg(m)}) – Soil gas data representative of conditions at site must be entered here
- 2) Depth of contamination or soil gas – This depth is the depth of the measured soil gas or the depth of free-product, soil and/or groundwater contamination.

Chemical Properties – These values will be automatically entered into the “Value Used” column if a chemical was entered in the chemical name field. Any value may be over-ridden by entering a value in the site-specific column.

Soil Properties – These fields are already filled in with the default values listed on Table 7-4 of the SAM Manual. If a level 2 or 3 evaluation is being done then the field values must be entered in the site-specific column.

Building Specifications

- a. Floor area of building - For a level 1 and level 2 evaluation, the model is insensitive to the floor area. This is because it is assumed that 100 percent of the floor area is experiencing vapor flux. For level 1 and 2 use a value of 1. For a level 3 evaluation, use the actual floor area.
- b. The percentage of floor area that flux occurs – For both level 1 and 2 analysis the value must be 100%. In a level 3 analysis this may be reduced based on site-specific conditions. Specific justification must be provided.
- c. Interior height – This is the height of the ceiling within the structure.

d. Exchange rate of air – The default values of air exchange rates are 0.5 building exchanges per hour for residential uses and 0.83 building exchanges per hour for commercial uses. Other values for air exchanges can be used if technical justification is provided. Generally for existing structures, either a certified industrial hygienist or a licensed heating and air conditioning engineer will have to provide an estimate of the normal air exchange rate for the building or portion of the building being evaluated. For new and/or proposed structures the design engineer of the ventilation system must provide an estimate of the normal air exchange rate for the building or portion of the building being evaluated.

e. Attenuation factor (crack factor) – The default values for the attenuation factor are:

Dirt floor (no slab)	=	1.0
Old slab	=	0.1
New/improved slab	=	0.01
Coated slab*	=	0.001

* To utilize the attenuation factor for a coated slab, documentation must be provide to demonstrate the coating material would be effective in reducing the vapor flux through the that slab to 0.001.

Outdoor Air Component – This element of the application calculates the contaminant concentration in outdoor air that is produced by vapors diffusing upward through soil that lies upwind of the building. Risk posed by outdoor air contamination alone can be evaluated by setting the building floor area equal to zero.

a. Downwind contamination length (L) - The downwind distance between the building and the contamination source. You can eliminate this contribution by entering “0.00” for downwind contamination length.

b. Wind speed – The average wind velocity in m/hr. Note, the default value of 16,000 m/hr entered in the application represents a wind velocity of approximately 10 miles/hr.

c. Height of building openings – This is generally 2 meters.

Exposure Scenario - The following are the common default values for residential and commercial exposure.

	<u>Residential</u>	<u>Commercial</u>
Body weight	child – 15 kg adult - 70 kg	child – 15 kg adult - 70 kg
Inhalation rate	child – 10 m3/day adult - 20 m3/day	child – 10 m3/day adult – 20 m3/day
Exposure duration	30 years	25 years
Hours per day	24 hours	12 hours
Days per week	7 days	5 days
Weeks per year	52 weeks	50 weeks

For the commercial level 2 and 3 evaluations, the exposure duration, hours per day, days per week and weeks per year can be modified based on realistic exposure time. Any modification must be justified and must be based on existing and/or future site uses. Additionally, any modifications to the exposure duration must be documented by providing relevant statistical data for the specific site use.

Health Risk Factors –

- a. Reference dose (inhalation) – This value will be automatically entered into the “Value Used” column if the chemical was entered in the chemical name field. Any value may be over-ridden by entering a value in the site-specific column. Specific justification must be provided when using values other than the default values.
- b. Slope factor (inhalation) - This value will be automatically entered into the “Value Used” column if the chemical was entered in the chemical name field. Any value may be over-ridden by entering a value in the site-specific column. Specific justification must be provided when using values other than the default values.

B. HEALTH RISK CALCULATIONS SPREADSHEET - This table provides the results of the health risk calculations.

C. PROPERTIES TABLE - This table is the lookup table for the chemical properties for the chemicals listed on the Input data Spreadsheet. The source of this data is presented on Table 7-2(a) in the SAM Manual.

D. HEALTH RISK FACTORS - This table is the lookup table for the health risk factors for the chemicals listed on the Input data Spreadsheet. The source of this data is presented on Table 7-1 in the SAM Manual.